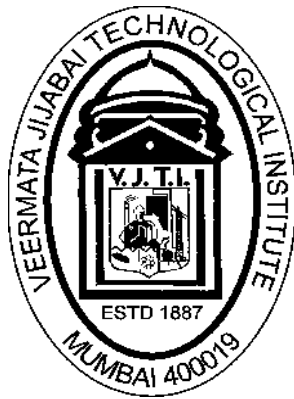


VEERMATA JIJABAI TECHNOLOGICAL INSTITUTE
(VJTI)
MATUNGA, MUMBAI 400 019

(Autonomous Institute affiliated to University of Mumbai)



Curriculum
(Scheme of Instruction & Evaluation and Course contents)

For
Two Year Postgraduate Programme
Leading to Master of Technology
(M Tech) Degree in
Mechanical Engineering with specialization in CAD/CAM & Automation

Implemented from the batch admitted in Academic Year 2022-23

Mechanical Engineering with specialization in CAD/CAM & Automation

Program Outcomes (POs)

PO1: An ability to independently carry out research /investigation and development work to solve practical problems in the area of CAD/CAM & Automation.

PO2: An ability to write and present a substantial technical report/document in the area of CAD/CAM & Automation.

PO3: Students should be able to demonstrate a degree of mastery in the area of CAD/CAM & Automation. The mastery should be at a level higher than the requirements in the appropriate bachelor program.



V J T I Veermata Jijabai Technological Institute
(Central Technological Institute, Maharashtra State, INDIA)
H. R. Mahajani Marg, Matunga, Mumbai 400019
Tel.No. +91 22 24198101-02 Fax +91 22 24102874
www.vjti.ac.in

(Autonomous Institute affiliated to University of Mumbai)

Curriculum

(Scheme of Instruction & Evaluation and Course contents)

For

Two Year Postgraduate Programme

Leading to Master of Technology

(M Tech)

In

Mechanical Engineering (with Specialization in CAD/CAM & Automation)



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M.Tech. in Mechanical Engineering (with specialization in CAD/CAM & Automation)

Scheme of Instruction and Evaluation

SEMESTER I

Scheme of Instruction					Scheme of Evaluation			
Sr. No	Course Code	Course Title	L-T-P	Credits	TA	MST	ESE	ESE hours
1.	MECC5001S	Computational Methods	3-0-0	3	20	20	60	3
2.	MECC5011S	Computer Aided Design	3-0-0	3	20	20	60	3
3.	MECC5012S	Rapid Manufacturing	3-0-0	3	20	20	60	3
4.		Programme elective 1	3-1-0	4	20	20	60	3
5.		Programme elective 2	3-1-0	4	20	20	60	3
6.		Open elective 1	3-0-0	3	20	20	60	3
7.	MECC5071L	Laboratory-1 Computational Methods Laboratory	0-0-2	1	60% CIE		40	-
8.	MECC5072L	Laboratory-2 Computer Aided Design Laboratory	0-0-2	1	60% CIE		40	-
9.	MECC5073L	Laboratory-3 Rapid Manufacturing Laboratory	0-0-2	1	60% CIE		40	-
10.		Liberal Learning	0-0-2	1	100% CIE		-	-
			28	24				

abbreviations **L** Lecture, **T** Tutorial, **P** Practical, **TA** Teacher Assessment / Term work Assessment, **MST** Mid Semester Test, **ESE** End Semester Written Examination, **CIE** Continuous In-semester Evaluation



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SEMESTER II

Scheme of Instruction					Scheme of Evaluation			
Sr. No	Course Code	Course Title	L-T-P	Credits	TA	MST	ESE	ESE hours
1.	MECC5002S	Research Methodology & IPR	3-0-0	3	20	20	60	3
2.	MECC5013S	Robotics & Automation	3-1-0	4	20	20	60	3
3.	MECC5014T	Advanced Finite Element Analysis	3-1-0	4	20	20	60	3
4.		Programme elective 3	3-0-0	3	20	20	60	3
5.		Programme elective 4	3-0-0	3	20	20	60	3
6.		Open elective 2	3-0-0	3	20	20	60	3
7.	MECC5074L	Laboratory-4 Advanced finite Element Analysis Laboratory	0-0-2	1	60% CIE		40	-
8.	MECC5075L	Laboratory-5 Mechatronics Laboratory	0-0-2	1	60% CIE		40	-
9.	MECC5076L	Laboratory-6 Advanced Composite Materials Laboratory	0-0-2	1	60% CIE		40	-
10.		Liberal Learning	0-0-2	1	100% CIE		-	-
			28	24				

abbreviations **L** Lecture, **T** Tutorial, **P** Practical, **TA** Teacher Assessment / Term work Assessment, **MST** Mid Semester Test, **ESE** End Semester Written Examination, **CIE** Continuous In-semester Evaluation



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List of Programme Elective 1

Sr. No.	Course Code	Course Title
1.	MECC5021T	Design for Manufacturing & Assembly
2.	MECC5022T	Industry 4.0 and IIOT
3.	MECC5023T	Tools For Effective Experimentation

List of Programme Elective 2

Sr. No.	Course Code	Course Name
1.	MECC5031T	Characterization of Engineering Materials
2.	MECC5032T	Computer Integrated Manufacturing
3.	MECC5033T	Geometric Dimensioning & Tolerancing

List of Programme Elective 3

Sr. No.	Course Code	Course Name
1.	MECC5041S	Mechatronics
2.	MECC5042S	Product Life Cycle Management
3.	MECC5043S	Machine Tool Design
4.	MECC5044S	Product Design & Development

List of Programme Elective 4

Sr. No.	Course Code	Course Name
1.	MECC5051S	Advanced Composite Materials
2.	MECC5052S	Design for Additive Manufacturing
3.	MECC5053S	Manufacturing System Simulation
4.	MECC5054S	Virtual Reality, Augmented Reality & Mixed Reality

List of Open Elective 1

Sr. No.	Course Code	Course Title
1.	MECC5061S	3D Printing
2.	MECC5062S	Design Thinking and Innovation

List of Open Elective 2

Sr. No.	Course Code	Course Title
1.	MECC5063S	Robotics
2.	MECC5064S	Operations Research



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SEMESTER III

Scheme of Instruction					Scheme of Evaluation
Sr. No	Course Code	Course Title	L-T-P	Credits	
1.	MECC5091D	Skill Based Course (Project Stage -I)	---	5	100% CIE
2.	MECC5092D	Skill Based Course (Project Stage -II)	---	5	100% CIE
3.		Self Learning Course - 1	1-0-0	1	100% ESE of 3 hours or credit transfer
4.		Self Learning Course - 2	1-0-0	1	100% ESE of 3 hours or credit transfer
5.		Mandatory Non Credit Course	2-0-0	0	100% ESE of 3 hours or credit transfer
				12	

SEMESTER IV

Scheme of Instruction					Scheme of Evaluation
S. No	Course Code	Course Title	L-T-P	Credits	
1.	MECC5093D	Skill Based Course (Project Stage -III)	---	5	100% CIE
2.	MECC5094D	Skill Based Course (Project Stage -IV)	---	7	100% CIE
				12	

SEMESTER-I

Programme Name	<i>Masters of Technology in Mechanical Engineering with Specialization in CAD/CAM & Automation</i>
Course Code	MECC5001S
Course Title	Computational Methods

Course Outcomes

After completion of course, students would be able to

1. Solve algebraic equations, Eigen value problems
2. Analyze data using interpolation and regression methods.
3. Solve ordinary and partial differential equations using numerical techniques

Course Contents

Introduction

Engineering problems and computational methods; Introduction to numerical methods and analysis.

Error Analysis

Approximations; Round-off and Truncation errors; Backward and Forward error analysis

Roots of Nonlinear Equations

Bisection method, Regula Falsi, Secant method, Fixed point Method; Newton-Raphson method; Multiple roots; Roots of system of non-linear equations; Analysis and order of convergence; Polynomials Mueller's method, Bairstow's method.

Solution of System of Linear Equations

Direct methods (Gauss Elimination, Gauss-Jordan, LU decomposition, Thomas Algorithm); Perturbation analyses of direct methods matrix and vector norms, condition number of matrix; Iterative methods (Jacobi and Gauss-Seidel); convergence criteria for Jacobi and Gauss Seidel iterative methods, rate of convergence of iterative methods. Successive over Relaxation.

Solution of System of Nonlinear Equations

Iterative methods, Fixed Point iteration, Newton-Raphson method.

Approximation of functions

Approximation using polynomials (Simple, least squares estimation, orthogonal basis functions, Tchebycheff and Legendre polynomials); Interpolation (Newton's divided difference and Lagrange interpolating polynomials, Spline interpolation); Regression

Eigen values and Eigen vectors

Power, inverse power, and inverse power method with shift, Fadeev-Leverrier method for the formulation of the Characteristic polynomials and QR decomposition

Numerical Differentiation

Introduction to finite difference approximations, Derivation of generalized finite difference approximation of any order and accuracy, truncation error analysis, Richardson's extrapolation

Numerical Integration

Newton-Cotes integration formula, Romberg integration and Gauss Legendre quadrature; Ordinary

Ordinary Differential Equations (Initial Value Problems)

Euler's method, Multi-step methods, Runge-Kutta methods, Predictor Corrector Methods. Stiff ODEs. System of IVPs, Stiff problems and Gear's method

Ordinary Differential Equations (Boundary Value Problems)

Decomposition into Linear System of ODEs, Shooting and direct methods;

Partial Differential Equations Introduction to solution of PDEs, Parabolic (diffusion equation and advective-diffusion equation), Elliptic (Laplace equation) and Hyperbolic (Wave equation) equations; Explicit and Implicit Methods, Crank Nicholson Method

Recommended Reading

1. Steven C. Chapra and Raymond P. Canale, Numerical Methods for Engineers, McGraw Hill
2. Santosh Gupta, Numerical Methods for Engineers, New age international publishers
3. J.B. Doshi, Differential Equations for Scientists and Engineers, Narosa, 2010
4. Kreyszig, Erwin, I.S., Advanced Engineering Mathematics, Wiley, 1999
5. C. F. Gerald and P.O. Wheatley, Applied Numerical Analysis, Pearson Education Asia, New Delhi, Sixth Edition, 2006.

Programme Name	<i>Master of Technology in Mechanical Engineering with specialization in CAD/CAM & Automation</i>
Course Code	MECC5011S
Course Title	Computer Aided Design

Course Outcomes

After completion of course, students would be able to

1. Evaluate mathematical transformations and projections of rigid bodies.
2. Design & model curves, surfaces & solids.
3. Represent objects realistically
4. Develop codes to solve engineering problems.

Course Contents

Introduction

Introduction to CAD. Role of CAD in Mechanical Engineering, Design process, software tools for CAD, Scan Conversion, Geometric modelling.

Transformations in Geometric Modelling

Introduction, Translation, Scaling, Reflection, Rotation in 2D and 3D. Homogeneous representation of transformation, Concatenation of transformations.

Representation of Curves

Analytic Curves, Composite Ferguson curves, Hermite Cubic Splines, curve Trimming and Blending, Bernstein polynomials, Bezier Curves, Bezier-subdivision, Degree elevation, Composite Bezier, Splines, B-spline basis functions, Properties of basic functions, Knot Vectors, NURBS.

Representation of Surfaces

Parametric representation, Planer, Sweep surfaces, Surface of revolution, Bi-linear , lofted, Coon's patch, Hermite, Bezier, B-Spline surfaces, Developable surfaces, Surfaces of revolution, Intersection of surfaces, Surface modelling.

Design of Solids

Solid entities, Boolean operations, B-rep of Solid Modelling, CSG approach of solid modelling, Data exchange formats, Geometric Modeling using Point Clouds, Reverse Engineering.

Feature Based Modeling

Feature recognition, types of features, feature recognition schemes, feature recognition methods, Artificial Intelligence for feature recognition.

Virtual Reality, Augmented Reality and Mixed Reality

Introduction to Geometric Modeling, Types of Geometric Modeling, Features of Wireframe, Surface and Solid models, Definition of VR , Features of VR, Real time Response, Optimization of the Rendering Process, Technologies used in VR, Stereo Displays, Interactions in VR, Tracking based interaction, Data Generation for VR, Haptic Rendering, Applications of VR, Simulation in VR, Augmented Reality, Mixed Reality.

Recommended Reading

1. Rogers & Adams , Mathematical Elements for Computer graphics, Tata McGraw –Hill, New Delhi, 2nd Edition, 2002
2. Michael E. Mortenson , Geometric Modeling, Tata McGraw Hill, 2013.
3. Saxena and B. Sahay, Computer-Aided Engineering Design, Anamaya Publishers, New Delhi, 2005
4. Ibrahim Zeid, R. Sivasubramanian, CAD/ CAM Theory & Practice, Tata McGraw Hill Publications, 5th edition, 2009
5. Kunwoo Lee, Principles of CAD/CAM/CAE systems, Addison-Wesley (1999).
6. Linda Jacobson, Garage Virtual Reality, Sams Publishing, 1994.
7. Ken Pimentel, Kevin Teixeira, Virtual Reality, Windcrest McGraw-Hill, 1st Edition, 2003.
8. John Vince, Virtual Reality Systems, Addison-Wesley. 1995.

Programme Name	<i>Masters of Technology in Mechanical Engineering with Specialization in CAD/CAM & Automation</i>
Course Code	MECC5012S
Course Title	Rapid Manufacturing

Course Outcomes

After completion of course, students would be able to

1. Understand and evaluate various existing Product Development processes
2. Develop new technologies in the field Rapid Prototyping & CNC Manufacturing
3. Generate innovative ideas to reduce time and cost by developing new methods and materials for the modern manufacturing industry.

Course Contents

Introduction

Product Developing Cycle, Definition of Rapid Product Development, Virtual prototypical and rapid manufacturing technologies, Physical Prototyping & rapid manufacturing technologies, Synergic integration technologies.

Rapid Prototyping Processes

Principal of Rapid Prototyping (RP), Various RP technologies, Selection of a suitable RP process for a given application, Status of outstanding issues in RP- accuracy, speed, materials (strength, homogeneity and isotropy), Emerging Trends. Applications and Case Studies Engineering Applications, Medical Applications.

Computer Numerical Control

Fundamentals of CNC machine tools, Programming of CNC machines, Tool path generation, Direct Numerical Control. Automatically Programmed Tool (APT).

Rapid Tooling

Introduction to Rapid Tooling, Indirect Rapid Tooling Processes, Direct Rapid Tooling Processes, Emerging Trends in Rapid Tooling.

Reverse Engineering

Need for Reverse Engineering, Digitizing Methods and its Principles, Types measurements, Contact & Non-contact Types, Coordinate Measuring Machine (CMM), Capture devices, Sensors, Scanning Methods, 3D scanners, Data representation, Data processing and manipulation techniques. Applications .

Rapid Manufacturing Processes

Definition of Rapid Manufacturing, Roadmap to Rapid Manufacturing, Comparison of Various Processes for Rapid Manufacturing of Metallic Objects, Rapid Manufacturing of Polymeric Objects, Rapid Casting, other RM Processes like Hybrid Layered Manufacturing, Material Translation, Segmented Object Manufacturing.

Processing of Polyhedral Data

Processing of Polyhedral Data Polyhedral BRep modeling, Introduction to STL format, Defects and repair of STL files, Overview of the algorithms required for RP&T and Reverse Engineering

Recommended Reading

1. Chua Chee Kai and Leong Kah Fai, Rapid Prototyping Principles and Applications in Manufacturing, John Wiley & Sons, 1997.
2. K.P.Karunakaran, Rapid Product Development & Manufacturing, IIT, Bombay, 1st edition, 2013.
3. Peter D. Hilton and Paul F. Jacobs (Editors.), Rapid Tooling Technologies and Industrial Applications, Marcel Dekker. 4th edition, 2000.
4. P. N. Rao., CAD/CAM, Tata McGraw Hill Publications, 3rd edition, 2010.
5. Todd Grimm, User's Guide to Rapid Prototyping, Society of Manufacturing Engineers, 1st edition, 2004.
6. Paul F. Jacobs, Stereo-lithography and Other RP&M Technologies from Rapid Prototyping to Rapid Tooling, SME/ASME, 1996.
7. N. Hopkinson, R. J. M. Hague, and P.M. Dickens, Rapid Manufacturing , An Industrial Revolution for the digital age, John Wiley & Sons, Ltd, 2nd edition, 2006.
8. Ken Pimentel, Kevin Teixeira, Virtual Reality, Windcrest/McGraw-Hill, 1st edition, 2003.
9. Andreas Gebhardt, Rapid Prototyping, Hanser Publishers, 2nd edition – 2003.
10. Rafiq Noorani, Rapid Prototyping Principles and Applications, John Wiley & Sons -1st edition, 2006.
11. Wasim Ahmed Khan, Abdul Raouf, Kai Cheng, Virtual Manufacturing, Springer, 2011

Programme Elective-I

Programme Name	<i>Master of Technology in Mechanical Engineering with specialization in CAD/CAM & Automation</i>
Course Code	MECC5021T
Course Title	Design for Manufacturing and Assembly

Course Outcomes

After completion of course, students would be able to

1. Understand the quality aspects of design for manufacture and assembly.
2. Identify the design factors and processes as per customer specifications.
3. Apply the concept of DFM for casting, machining, forming and assembly.
4. Apply the DFM method for a given product.

Course Contents

Introduction to DFM, DFMA

How Does DFMA Work, Reasons for Not Implementing DFMA, What Are the Advantages of Applying DFMA During Product Design?, Typical DFMA Case Studies, Overall Impact of DFMA on Industry.

Design for Manual Assembly

General Design Guidelines for Manual Assembly, Development of the Systematic DFA Methodology, Assembly Efficiency, Effect of Part Symmetry, Thickness, Weight on Handling Time, Effects of Combinations of Factors, Application of the DFA Methodology.

High speed Automatic Assembly & Robot Assembly

Design of Parts for High-Speed Feeding and Orienting, Additional Feeding Difficulties, High-Speed Automatic Insertion, General Rules for Product Design for Automation, Design of Parts for Feeding and Orienting, Product Design for Robot Assembly.

Design for Machining and Injection Molding

Machining Using Single-Point & Multi point cutting tools, Choice of Work Material, Shape of Work Material, Machining Basic Component Shapes, Cost Estimating for Machined Components, Injection Molding Materials, The Molding Cycle, Injection Molding Systems, Molding Machine Size, Molding Cycle Time, Estimation of the Optimum Number of Cavities, Design Guidelines.

Design for Sheet Metal working & Die Casting

Dedicated Dies and Press-working, Press Selection, Turret Press working, Press Brake Operations, Design Rules, The Die Casting Cycle, Auxiliary Equipment for Automation, Determination of the Optimum Number of Cavities, Determination of Appropriate Machine Size, Die Casting Cycle Time Estimation, Die Cost Estimation, Design Principles.

Design for Assembly Automation

Fundamentals of automated assembly systems, System configurations, parts delivery system at workstations, various escapement and placement devices used in automated assembly systems, Quantitative analysis of Assembly systems, Multi station assembly systems, single station assembly lines.

Recommended Reading

1. Geoffrey Boothroyd, Assembly Automation and Product Design, Marcel Dekker Inc., NY,

3rd Edition,2010.

2. Geoffrey Boothroyd, Hand Book of Product Design, Marcel Dekker Inc., NY, 1992.
3. A K Chitale and R C Gupta, Product Design and Manufacturing, PHI, New Delhi, 2003.
4. J. G. Bralla, Design for Manufacturability Handbook, 2nd edition, McGraw-Hill Professional, 1998. ISBN 978-0070071391.

Programme Name	<i>Master of Technology in Mechanical Engineering with specialization in CAD/CAM & Automation</i>
Course Code	MECC5022T
Course Title	Industry 4.0 and IIoT

Course Outcomes

The student should be able to

1. Understand key concepts of Industry 4.0
2. Understand the drivers and enablers of Industry 4.0
3. Learn about various IIoT-related protocols
4. Build simple IIoT Systems using Arduino and Raspberry Pi

Course Contents

Fundamentals of Industry 4.0

Industry 4.0 Globalization and Emerging Issues, The Fourth Revolution, Lean Production Systems, Mass Customization, Smart and Connected Business Perspective, Smart Factories, Industry 4.0 Cyber Physical Systems and Next Generation Sensors, Collaborative Platform and Product Lifecycle Management, Augmented Reality and Virtual Reality, Big Data and Advanced Analysis, Data Analytics in Manufacturing such as Advanced Sensor Technologies, Artificial Intelligence, Internet of Robotic Things, Cloud Robotics.

Introduction to IIoT

Architectural Overview, Design principles and needed capabilities, IoT Applications, Sensing, Actuation, Basics of Networking, M2M and IoT Technology Fundamentals- Devices and gateways, Data management, Business processes in IoT, Everything as a Service (XaaS), Role of Cloud in IoT, Security aspects in IoT.

Elements of IIoT

Hardware Components- Computing (Arduino, Raspberry Pi), Communication, Sensing, Actuation, I/O interfaces. Software Components- Programming API's (using Python/Node.js/Arduino) for Communication Protocols-MQTT, ZigBee, Bluetooth, CoAP, UDP, TCP.

IIoT Application Development

Solution framework for IoT applications- Implementation of Device integration, Data acquisition and integration, Device data storage- Unstructured data storage on cloud/local server, Authentication, authorization of devices.

Smart Applications

Online Predictive Modeling, Monitoring and Intelligent Control of Machining/Manufacturing and Logistics/Supply Chain Processes; Smart Energy Management of manufacturing processes and facilities, Agriculture, Healthcare, Home Automation

Recommended Reading

1. Introduction to Industrial Internet of Things and Industry 4.0, Sudip Misra, Chandana Roy, Anandarup Mukherjee, CRC Press, 2020.
2. Industry 4.0 the industrial internet of things, Alasdair Gilchrist, Apress Publisher, 2016.
3. Industry 4.0 Managing The Digital Transformation, Alp Ustundag, EmreCevikkan, Springer, 2018.
4. Digital Manufacturing and Assembly Systems in Industry 4.0 (Science, Technology, and Management), Kaushik Kumar , Divya Zindani J,Paulo Davim, CRC Press.
5. Smart Manufacturing by Shoukat Ali; Publisher LAP LAMBERT Academic Publishing(10 August 2016)
6. Introduction to Internet of Things A practical Approach, Dr. SRN Reddy, Rachit Thukral and Manasi Mishra, ETI Labs,2010
7. The Internet of Things Enabling Technologies, Platforms, and Use Cases, Pethuru Raj and Anupama C. Raman, CRC Press, 2012
8. Designing the Internet of Things, Adrian McEwen, Wiley, 2015
9. A. McEwen and H. Cassimally, Designing the Internet of Things, 1st edition, Wiley, 2013, ISBN-10 111843062X.
10. Industry 4.0, AI, and Data Science Research Trends and Challenges, Vikram Bali,Kakoli Banerjee, Narendra Kumar , Sanjay Gour, Sunil Kumar Chawla
11. The concept Industry 4.0- An Empirical Analysis of Technologies and Applications in Production Logistics, Christoph Jan Bartodziej, Springer Gabler, 2017.

Programme Name	Master of Technology in Mechanical Engineering with specialization in CAD/CAM & Automation
Course Code	MECC5023T
Course Title	Tools For Effective Experimentation

Course Outcomes

After completion of course, students would be able to

1. Analyze various types of data using statistical tools
2. Understand the experimental planning.
3. Understand the effect of various factor on output using design of experiments.
4. Analyze the importance of curvature effect using surface response methodology.

Course Contents

Graphical Data analysis tools

Stem and leaf plot, Dot plot, Box plot Distribution of sample data - Normal distribution, t distribution Normal Probability Plotting on ordinary graph paper, Interpretation Testing a new method for improvement – Variability known from past, Variability estimated from the experiment, Comparing two methods - Randomised samples, Paired samples, Comparing more than two methods simultaneously- ANOVA.

Experimental strategies - Deficiencies of one factor at a time experiments, Problems in analysis of past data, Necessity for randomization

Basics of Experimental Design - Terminology, Two level factorials, Estimation of effects and interactions, Yates algorithm, Unreplicated experiments - judging significance, Testing for significance in replicated experiments. Developing mathematical model equations, calculating residuals, checking whether experiment has been conducted satisfactorily.

Handling non-normal response – Transformations

Choosing the number of experiments, Testing whether linear model is satisfactory, How to handle uncontrollable factors, How to deal with difficult to randomise factors. Dealing with large number of factors, Fractional Factorial experiments and Plackett Burman Designs, How to minimise possible confusion, Design Resolution, Sequential experimentation strategies, Folding over.

Determining optimum conditions experimentally - Central Composite Designs, D-Optimal Designs, Response Surface methods, Mixture experiments. Experiments to determine variability and minimise it. Training in Design Expert, software for DoE. Individual Design Project, presentation and discussion. Applications/Case Studies in Research, Quality Improvement, Product Development.

Recommended Reading

1. Anderson, Mark J., & Whitcomb, Patrick J., Doe Simplified Practical Tools for Effective Experimentation, Productivity Press, USA.
2. Lawson, John & Erjavec, John, Modern Statistics for Engineering and Quality Improvement, Thomson Duxbury, 2000, Indian EPZ edition
3. Box, George E. P., Hunter, William, G., & Hunter, Stuart, J., Statistics for Experimenters, John Wiley & Sons inc, 1976.

Programme Elective-II

Programme Name	<i>Master of Technology in Mechanical Engineering with specialization in CAD/CAM & Automation</i>
Course Code	MECC5031T
Course Title	Characterization of Engineering Materials

Course Outcomes

The student should be able to

1. Identify advanced techniques available for characterization of materials.
2. Select a characterization technique to evaluate the behavior of materials
3. Analyze defects and failure surfaces of materials
4. Analyze the characterization results by various equipment

Course Contents

Introduction

Overview of the course; materials classification and their properties, Importance of materials selection, property classification, Criteria for selection of materials, Ashby charts for materials selection, Engineering Design process and the role of materials; material property charts; selection of materials based on function, objective, constraints and free variables; examples of material selection for typical applications.

Computer aided materials selection

Selection of process based on material classification; pencil curve approach; material selection for multiple constraints and multiple objective cases; multiple constraints and conflicting objectives. Co-selection of material and shape; concept of macroscopic and microscopic shape factors; Four quadrant method of material selection. General Properties of plastics, polymers and elastomers; visco-elastic properties; short-term and long-term properties of plastics.

High temperature materials

Families of super alloys and their characteristics; creep and fatigue resistance of super alloys; role of precipitates in strengthening of super alloys; repair of super alloys after creep damage; coatings for high temperature materials.

Fundamentals of ceramics

General properties, applications of ceramics for critical applications. Design considerations. Surface treatment of materials using coatings; type of coatings; PVD and CVD coatings. Basics of electro-plating and electro-less plating.

Physical characterization of materials

Optical Microscopy, SEM, TEM, Density, Void content in materials, Electron Probe Micro Analyzer (EPMA), Atomic Force Microscopy (AFM), Thermogravimetric analysis (TGA), nano indentation, NMR spectroscopy, EDAX, FTIR, XRD.

Mechanical characterization

Tensile test, flexural test, compression test, ILSS, creep, fatigue, Hardness, Impact test, Fracture toughness test, Principle, construction and operation working parameters, equipment operation. selection of plastics based on mechanical properties, degradation due to environment, of laminates.

Recommended Reading

1. M.F. Ashby, Materials Selection in Mechanical Design, Butterworth Heinemann, 4th Edition, 2010
2. Yang Leng, Materials Characterization-Introduction to Microscopic and Spectroscopic Methods, John Wiley & Sons (Asia) Pte Ltd, 2008
3. ASM Handbook Materials Characterization, ASM International, 2008.
4. V. T. Cherapin and A. K. Mallik, Experimental Techniques in Physical Metallurgy, Asia Publishing House, 1967.
5. Dieter, George E., Mechanical Metallurgy, McGraw Hill, 2nd Edition, 2005
6. Crawford, R. J., Plastics Engineering, Butterworth-Heinemann, 3rd Edition, 2002.
7. Donachie, M. J. and Donachie, S. J., Super alloys A technical guide, ASM International, 2002.

Programme Name	<i>Master of Technology in Mechanical Engineering with specialization in CAD/CAM & Automation</i>
Course Code	MECC5032T
Course Title	Computer Integrated Manufacturing

Course Outcomes

After completion of the course the student should be able to

1. Analyze various existing manufacturing processes.
2. Develop various automation strategies for industrial applications using Computer Aided Manufacturing Systems.
3. Apply new technologies like CE, MRP, ERP, PPC in the field Manufacturing.
4. Integrate the Manufacturing Systems with Manufacturing Support systems through Computer networking and Computer database.

Course Contents

Introduction

Introduction to CIM. Evolution of Computer Integrated Manufacturing (CIM), CIM Hardware and Software, Product development through CIM. Computer-Aided Manufacturing (CAM). CAD/CAM Integration. Review of automation and control technologies.

Manufacturing Operations

Manufacturing Industries and Products, Manufacturing Operations, Cost of Manufacturing Operations

Building blocks of Computer Integrated Manufacturing

FMS system design, Group Technology system design, development and utilization, Computer simulation of FMS, Packages available, Illustrative examples, CNC issues in file transfer and integration, Tooling on CNC, Fixtures on CNC, Tool handling systems. Material handling and storage systems like Robots, AGVS, systems, AS/RS etc., Development for total material handling system. Automatic inspection systems.

Information System and Manufacturing

Manufacturing resources planning, Role of MRP-II in CIM system, CAPP, Scheduling Enterprise Resources Planning, Supply chain management. Concurrent Engineering. Production Planning and Control Systems. Lean and Agile Manufacturing. Web-based manufacturing.

Computer Networking

CIM models, Fundamentals of networking, Shop floor data control, CIM database and CIM database requirements, Data Communication technologies. Automatic Data Acquisition technologies. Database Management technologies`

Recommended Reading

- 1 Groover, M. P., Automation production systems, and computer-integrated manufacturing, second edition, Prentice-Hall of India, New Delhi, 3rd edition, 2007.
- 2 Vajpayee, S. K., Principles of computer-integrated manufacturing, Prentice-Hall of India, New Delhi, 2005.
- 3 Roger Hannam, Computer-Integrated Manufacturing, From concepts to realization. Addison-Wiley 4th Edition, 2005.
- 4 P. Radhakrishnan and S. Subramanyan, CAD/CAM/CIM , New Age International Publishers, 2nd edition, 2008
- 5 P. N. Rao., CAD/CAM , Tata McGraw Hill Publications, 3rd edition, 2010.
- 6 Oavid I. Geotsch , Fundamentals of CIM Technology , Delmar Publishers, 1st edition, 1988
- 7 YoramKoren , Computer Control of Manufacturing systems, McGraw Hill, 1st edition, 1983
- 8 T. K. Kundra, P. N. Rao, N. K. Tewari, Numerical Control and Computer Aided Manufacture, Tata McGraw Hills, New Delhi., 1st edition, 1985

Programme Name	<i>Master of Technology in Mechanical Engineering with specialization in CAD/CAM & Automation</i>
Course Code	MECC5033T
Course Title	Geometric Dimensioning and Tolerancing

Course Outcomes

At the end of the course, the student will be able to

1. Interpret GDT symbols on a print.
2. Identify minimum and maximum material conditions
3. Measure and verify position tolerances with applied material conditions
4. Apply basic rectangular datum reference frames

Course Contents

Introduction

Scope, Definitions, Fundamental Rules, Units of Measure, Types of Dimensioning, Application of Dimensions, Dimensioning Features, Location of Features

Principles of Tolerancing

Direct Tolerancing Methods, Tolerance Expression, Interpretation of Limits, Single Limits, Tolerance Accumulation, Limits of Size, Applicability of Modifiers on Geometric Tolerance Values and Datum Feature References, Screw Methods, Gears and Splines, Boundary Conditions, Angular Surfaces, Conical Tapers, Flat Tapers, Radius, Tangent Plane, Statistical Tolerancing.

Symbology

Use of Notes to Supplement Symbols, Symbol Construction, Feature Control Frame Symbols, Feature Control Placement, Definition of Tolerance Zone, Tabulated Tolerances

Datum Reference Frames

Degrees of Freedom, Degrees of Freedom Constrained by Primary Datum Features, Regardless of Material Boundary, Constraining Degrees of Freedom of a Part, Datum Feature Simulator, Theoretical and Physical Application of Datum Feature Simulators, Datum Reference Frame, Datum Features and Controls, Specifying Datum Features in an Order of Precedence, Establishing Datums, Multiple Datum Features, Mathematically Defined Surface, Multiple Datum reference Frames, Functional Datum Features, Rotational Constraint about a Datum Axis or Point, Application of MMB, LMB and RMB to Irregular Features of Size, Datum Feature Selection Practical Applications, Simultaneous Requirements, Restrained Condition, Datum Reference Frame Identification, Customized Datum Reference Frame Construction, Application of a Customized Datum Reference Frame, Datum Targets

Form Tolerances

Form Control, Specifying Form Tolerances, Application of Free-State Symbol

Orientation Tolerances

Orientation Control, Orientation Symbols, Specifying Orientation Tolerances, Tangent Plane, Alternative Practice

Location Tolerances

Positional Tolerancing, Positional Tolerancing Fundamentals – I and II, Pattern Location, Coaxial Feature Controls, Tolerancing for Symmetrical Relationships

Profile Tolerances

Profile, Tolerance Zone Boundaries, Profile Applications, Material Condition and Boundary Condition Modifiers as Composite Profile, Multiple Single-Segment Profile Tolerancing, Combined Controls

Runout Tolerances

Runout, Runout Tolerance, types of Runout Tolerances, Applications, Specification.

Recommended Reading

1. Geometric Dimensioning and Tolerancing by P.S. Gill, (Publ.) S. K. Kataria & Sons, 2009
2. Geometric Dimensioning and Tolerancing Applications and Techniques for Use in Design Manufacturing, and Inspection, by James D. Meadows, CRC Press, 1995
3. Simplified GD & T Based on ASME-Y 14.5-2009 by Ashok Kumar 2nd Edition, Azuko Publishing 2009

Open Elective-I

Programme Name	Masters of Technology in Mechanical Engineering with Specialization in CAD/CAM & Automation
Course Code	MECC5061S
Course Title	3D Printing

Course Outcomes

After completion of course, students would be able to

1. Understand and evaluate various existing Product Development processes
2. Develop new technologies in the field Rapid Prototyping Manufacturing
3. Generate innovative ideas to reduce time and cost by developing new methods and materials for the modern manufacturing industry.

Course Contents

Rapid Product Development

Product Developing Cycle, Definition of Rapid Product Development, Virtual prototypical and rapid manufacturing technologies, Physical Prototyping & rapid manufacturing technologies, Synergic integration technologies

Rapid Prototyping Processes

Principal of Rapid Prototyping, Various RP technologies, Selection of a suitable RP process for a given application, Status of outstanding issue in RP- accuracy, speed, materials (strength, homogeneity and isotropy), Emerging Trends

Rapid Tooling

Introduction to Rapid Tooling, Indirect Rapid Tooling Processes, Direct Rapid Tooling Processes, Emerging Trends in Rapid Tooling

Reverse Engineering

Data Extraction, Data Processing

Applications and Case Studies

Engineering Applications, Medical Applications

Processing of Polyhedral Data

Polyhedral BRep modeling, Introduction to STL format, Defects and repair of STL files, Overview of the algorithms required for RP&Tand Reverse Engineering

Laboratory and Demonstration Sessions

Exercise using 3D CAD software,Preparation STL files processing, Making models on FDM RP machine, Demonstration of Silicon Rubber Molding and Application of post processing techniques on FDM parts.

Recommended Reading

1. Chua Chee Kai and Leong Kah Fai, Rapid Prototyping Principles and Applications in Manufacturing, John Wiley & Sons, 1997.
2. K.P.Karunakaran,Rapid Product Development & Manufacturing, IIT, Bombay, 1st edition, 2013.
3. Peter D. Hilton and Paul F. Jacobs (Editors.), Rapid Tooling Technologies and Industrial Applications, Marcel Dekker. 4th edition, 2000.

4. Todd Grimm, User's Guide to Rapid Prototyping, Society of Manufacturing Engineers, 1st edition, 2004.
5. Paul F. Jacobs, Stereo-lithography and Other RP&M Technologies from Rapid Prototyping to Rapid Tooling, SME/ASME, 1996.
6. N. Hopkinson, R. J. M. Hague, and P.M. Dickens, Rapid Manufacturing , An Industrial Revolution for the digital age, John Wiley & Sons, Ltd, 2nd edition, 2006.
7. Ken Pimentel, Kevin Teixeira, Virtual Reality, Windcrest/McGraw-Hill, 1st edition, 2003.
8. Andreas Gebhardt, Rapid Prototyping, Hanser Publishers, 2nd edition – 2003.
9. Rafiq Noorani, Rapid Prototyping Principles and Applications, John Wiley & Sons -1st edition, 2006.
- 10 Wasim Ahmed Khan, Abdul Raouf, Kai Cheng, Virtual Manufacturing, Springer, 2011

Programme Name	<i>Master of Technology in Mechanical Engineering with specialization in CAD/CAM & Automation</i>
Course Code	MECC5062S
Course Title	Design Thinking and Innovation

Course Outcomes

After completion of course, students would be able to

1. Understand the concept that drives design thinking.
2. Translate the customer needs into product specifications.
3. Learn the techniques for creating ideas.
4. Develop the ability to create and test prototypes.

Course Contents

Introduction to Design thinking

Phases of design thinking Empathize, Define, Ideate, Prototype, Test, Roots of design thinking, Human Centered Design Methods and Approaches

Understanding the need

Knowing Your Users, Identifying Needs of Customers, Designing with Empathy, Methods for Empathetic Design, Designing for Diversity & Inclusion

Ideation

Ideation Techniques, Tools for Fostering Creativity, Evaluation of Ideas, Immersive Learning Exercises

Prototyping & Testing

Proof of Concept, Minimum Value Proposition Designing, Tooling and Building, Learning from Failed Designs

Product Development

New Product Development Processes, Design for Products & Services, Sustainability through Design, Thinking Lean & Agile Product/ Service Design.

Applications of Design Thinking

Case Studies on application of design thinking in different fields such as health care, consumer products, solving social problems etc.

Recommended Reading

1. Michael G Luchs, Design Thinking by John Wiley & Sons Inc., 2016
2. Gravin Ambrose, Design Thinking, AVA Publishing
3. Tim Brown, Change by Design, Harper Collins E-books
4. Christian Mueller-Roterberg, Hand book of Design Thinking, Kindle Direct Publishing ISBN 978-1790435371
5. Ulrich, Karl T., Design Creation of Artifacts in Society, 2011, <https://ssrn.com/abstract=1951106> or <http://dx.doi.org/10.2139/ssrn.1951106>

Laboratory Courses

Programme Name	<i>Masters of Technology in Mechanical Engineering with Specialization in CAD/CAM & Automation</i>
Course Code	MECC5071L
Course Title	Laboratory-1 Computational Methods Laboratory

Course Outcomes

After completion of course, students would be able to

1. Write codes that use computational methods to numerically solve problems in a variety of disciplines in Mechanical Engineering.
2. Learn open source packages that implement popular computational methods.
3. Apply the mathematical concepts the Computational Methods course.

Course Contents

The lab will involve development of programs based on numerical methods using Python/Matlab/Scilab etc. for solving variety of common Mechanical Engineering problems.

1. Program for solving system of linear equations
2. Program for regression analysis and curve / function fitting to a given data set
3. Program for root finding on non-linear equation
4. Program for Numerical Differentiation and Integration
5. Program for solving differential equations based on Runge-Kutta formulation
6. Program for Boundary Value Problems in Ordinary and Partial Differential Equations

Programme Name	<i>Master of Technology in Mechanical Engineering with specialization in CAD/CAM & Automation</i>
Course Code	MECC5072L
Course Title	Laboratory-2 Computer Aided Design Laboratory

Course Outcomes

After completion of course, students would be able to

1. Plot geometric entities using scan conversion algorithm
2. Develop computer codes for curves and surfaces
3. Model the part and geometries using commercial CAD software
4. Understand use of AI in CAD modeling & VR/AR/MR applications

List of experiments

1. Development of computer code for scan conversion algorithms
2. Development of computer code for transformations
3. Development of computer code for curves
4. Development of computer code for surfaces
5. Sketching and Part modelling using CAD software
6. Surface modelling using CAD software
7. Assembly modelling and drafting using CAD software
8. Creating VR/AR/MR applications using Unity software
9. Case studies on use of AI in CAD modeling

Programme Name	<i>Master of Technology in Mechanical Engineering with specialization in CAD/CAM & Automation</i>
Course Code	MECC5073L
Course Title	Laboratory-3 Rapid Manufacturing Laboratory

Course Outcomes

After completion of course, students would be able to

1. Process 'STL' files from 3D models and Assemblies
2. Build rapid prototyping parts using FDM process
3. Apply surface finish enhancement techniques on FDM parts.
4. Develop CNC part programmes.

List of Experiments

1. Development of 3D CAD models and Assemblies using CAD Software to generate STL files.
2. Processing of STL files of 3D modelled parts/assemblies
3. Building Rapid Prototyping (FDM) parts/assemblies
4. Applying post processing techniques on FDM parts
5. Surface roughness measurement of FDM parts.
6. Tool path generation using CAM software Introduction to 'CAM' software, Importing and modifying 3D geometry, Selecting tools, Generating operation, specific tool path, Generating G-codes and M-codes in 'CAM' software
7. CNC part programming on CNC machine Introduction to existing CNC machine in the lab, Introduction and details of its corresponding control software, Machining parts, as per given drawings.
8. Using Coordinate Measuring Machine Demonstration on existing CMM machine, Introduction and details of controlling software, Measuring various components.

SEMESTER-II

Programme Name	<i>Master of Technology in Mechanical Engineering with specialization in CAD/CAM & Automation</i>
Course Code	MECC5002S
Course Title	Research Methodology and IPR

Course Outcomes

After completion of course, students would be able to

1. Understand research problem formulation and approaches of investigation of solutions for research problems.
2. Learn ethical practices to be followed in research and apply research methodology in case studies and acquire skills required for presentation of research outcomes
3. Discover importance of Intellectual Property Rights.
4. Promote Intellectual Property Right and patenting.

Course Contents

Research Problem

Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem. Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations

Literature Review

Effective literature studies approaches, analysis, Plagiarism, Research ethics,

Technical Writing

Effective technical writing, how to write report, Paper, Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee

Nature of Intellectual Property

Patents, Designs, Trade and Copyright. Process of Patenting and Development technological research, innovation, patenting, development. International Scenario International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.

Patent Rights

Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications.

New Developments in IPR

Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies.

Recommended Reading

1. Ranjit Kumar, Research Methodology A Step by Step Guide for beginners, 2nd Edition
2. C.R. Kothari, Research Methodology Methods and Techniques
3. Halbert, Resisting Intellectual Property, Taylor & Francis Ltd., 2007.
4. Mayall, Industrial Design, McGraw Hill, 1992.
5. Niebel, Product Design, McGraw Hill, 1974.
6. T. Ramappa, Intellectual Property Rights under WTO, S. Chand, 2008

Programme Name	<i>Master of Technology in Mechanical Engineering with specialization in CAD/CAM & Automation</i>
Course Code	MECC5013S
Course Title	Robotics & Automation

Course Outcomes

After completion of course, students would be able to

1. Analyze various types Robots and their applications
2. Understand terminologies related to Kinematics of Robotics.
3. Analyze basics of motion programming as per kinematics
4. Apply logic for selection of robotic systems and its application in automation.

Course Contents

Introduction to Robotics

Brief History, Basic Concepts of Robotics such as Definition , Three laws, Elements of Robotic Systems i.e. Robot anatomy, DOF, Misunderstood devices etc., Classification of Robotic systems on the basis of various parameters such as work volume, type of drive, etc., Associated parameters i.e. resolution, accuracy, repeatability, dexterity, compliance, etc., Introduction to Principles & Strategies of Automation, Types & Levels of Automations, Need of automation, Industrial applications of robot. Robotics application current and future.

Grippers and Sensors for Robotics

Grippers for Robotics - Types of Grippers, Guidelines for design for robotic gripper, Force analysis for various basic gripper systems. Sensors for Robots - Types of Sensors used in Robotics, Classification and applications of sensors, Characteristics of sensing devices, Selections of sensors. Need for sensors and vision system in the working and control of a robot.

Drives and Control for Robotics

Drive - Types of Drives, Types of transmission systems, Actuators and its selection while designing a robot system. Control Systems Types of Controllers, Introduction to closed loop control

Robot Kinematics

Spatial Descriptions positions, orientations, and frame, mappings changing description from frame to frame, Operators translations, rotations and transformations, transformation arithmetic, compound Transformations, inverting a transform, transform equations, Euler Angles, Fixed Angles, Euler Parameters. Manipulator Kinematics, Link Description, Link to reference frame connections, Denavit-Hartenberg Approach, D-H Parameters, Position Representations, Homogeneous Transformation Matrix, Forward Kinematics. Inverse Kinematics, Geometric and analytical approach.

Trajectory Planning

Introduction, path vs trajectory, joint space vs Cartesian space description, basics of tractor planning, joint space trajectory planning Third order polynomial, Fifth order polynomial, linear segment with parabolic blends, linear segment with parabolic blends and via points, higher order trajectories, etc.

Computer vision for robotic system

Imaging Components, Image Representation, Hardware Considerations, Picture Coding, Object Recognition and Categorization, Software Considerations, Need for Vision Training and

Adaptations, Review of Existing Systems, etc.

Computer Considerations for Robotic Systems

Objectives, Motivation, Architectural Considerations, Hardware Considerations, Computational Elements in Robotic Applications, Real-Time Considerations, Robot Programming, Path Planning, etc.

Manufacturing Systems

Fundamentals of Manufacturing systems, Group Technology(GT), Flexible Manufacturing Systems(FMS), Transfer lines, Material handling systems, Automated Guided Vehicles (AGVs), Automated Storage & Retrieval Systems(ASRS).

Related Topics in Robotics

Socio-Economic aspect of robotisation. Economical aspects for robot design, Safety for robot and standards, Introduction to Artificial Intelligence, AI techniques, Need and application of AI, New trends & recent updates in robotics.

Recommended Reading

1. Robert J Schilling, Fundamentals of Robotics Analysis & Control Pearson Education, Inc., 2007.
2. S. B. Niku, Introduction to Robotics – Analysis, Control, Applications, 3rd edition, John Wiley & Sons Ltd., 2020
3. R. K. Mittal, I. J. Nagrath, Robotics and Control, TATA McGraw Hill Publishing Co Ltd, New Delhi, 2003.
4. Groover, M. P., Automation production systems, and computer-integrated manufacturing, second edition, Prentice-Hall of India, New Delhi, 3rd edition, 2007.
5. R. D. Klafter, Thomas A. Chmielewski, and Michael Negin, Robotic Engineering – An Integrated Approach, EEE, Prentice Hall India, Pearson Education Inc., 2009.
6. Vajpayee, S. K., Principles of computer-integrated manufacturing, Prentice-Hall of India, New Delhi, 2005.
7. J. Angeles, Fundamentals of Robotic Mechanical Systems Theory Methods and Algorithms, Springer, 1997
8. S. K. Saha, Introduction to Robotics 2nd edition, TATA McGraw Hills Education, 2014.
9. Ashitava Ghosal, Robotics Fundamental Concepts and Analysis, Oxford University Press, 2006.
10. T. C. Manjunath, Fundamentals of Robotics, Nandu Printers and Publishers, 2010.

Programme Name	<i>Masters of Technology in Mechanical Engineering with Specialization in CAD/CAM & Automation</i>
Course Code	MECC5014T
Course Title	Advanced Finite Element Analysis

Course Outcomes

After completion of course, students would be able to

1. Formulate numerical model for a given system.
2. Obtain numerical Solutions for boundary value problems.
3. Solve mechanical engineering problems using Finite Element Methods.

Course Contents

Introduction to Finite Element Analysis

Introduction, Basic concept of Finite Element analysis, Discretization of continuum, Stiffness Matrix and Boundary Conditions, Introduction to elasticity, Plane Stress and Plain strain Problem

Finite Element Formulation Techniques

Virtual Work and variational principle, Variational Formulation of Boundary Value problem, Variational Method such as Ritz and weighted Residual methods. Galerkin Method Potential Energy Approach, Displacement Approach

Element Properties

Natural coordinates, Triangular Elements, Rectangular Elements, Lagrange and Serendipity Elements, Solid Elements, Isoparametric Formulation, Stiffness Matrix for Isoparametric Elements, Numerical Integration

Displacement Models

Convergence requirements, Shape functions, Element stresses and strains, Strain-Displacement Matrix for Bar Element, Strain Displacement Matrix for CST Element, Strain Displacement Relation for Beam Element

Analysis of Frame Structure

Stiffness of Truss Members, Analysis of Truss, Stiffness of Beam Members, Finite Elements analysis of Beam

FEM for Two Dimensional Solids

Constant and Linear Stain Triangle, Rectangular Elements, Finite Element Formulation for 2D elements. Axisymmetric Elements. Finite Element Formulation of Axisymmetric Elements Heat Transfer by conduction and convection for one dimensional and two-dimensional elements

Dynamic Analysis Using FEA

Introduction, Vibration Problems, Equation of motion Based on weak form and Lagrange's Approach, Consistent and Lumped mass Matrices, Properties and Solution of Eigen Value Problems, Transient Vibration Analysis, Thermal transient-Unsteady heat Transfer in a Pin-Fin

Nonlinear Analysis

Introduction, Geometric and Material Nonlinearity, Stability Problems, Elastoplastic analysis by FEM

Recommended Reading

1. Finite Element Analysis By S.S.Bhavikatti, New Age International Publication.
2. Introduction to FEM by Desai and Abel
3. The Finite Element Method for Solid and Structural Mechanics –Zienkiewicz & Taylor, Elsevier Publications
4. Finite Element Analysis by J.N. Reddy, McGraw Hill Book Co.
5. Finite Element Method in Engineering by S.S.Rao, Pergamon Press
6. Textbook on Finite Element Analysis by P. Seshu, Prentice Hall Publications
7. Finite Element Analysis by Bathe and Wilson
8. Introduction to Finite Element Analysis by T. Chandrupatla and A. D. Belegundu, Prentice Hall
9. Finite Element Modeling For Stress Analysis for Robert D.Cook , John Wiley & Sons.
10. Computational Elasticity by Mohammad Ameen, Narosa Publishing House.

Programme Elective-III

Programme Name	<i>Master of Technology in Mechanical Engineering with specialization in CAD/CAM & Automation</i>
Course Code	MECC5041S
Course Title	Mechatronics

Course Outcomes

After completion of course, students would be able to

1. Enable the student to understand the modern mechatronics components
2. Present the underlying principles and alternatives for mechatronics systems design
3. Evaluate the design and programming for Microprocessor,. Microcontroller,. PLC and application of control theory

Course Contents

Introduction of Mechatronics and its block diagram representation

Key elements of mechatronics, Applications of Mechatronics domestic, industrial etc. Representation of mechatronic system in block diagram and concept of transfer function for each element of mechatronic system, Reduction methods and its numerical treatment for represented block diagram

Selection of Sensors & Actuators

Sensors Criteria for selection of sensors based on requirements, principle of measurement, sensing method, performance chart etc. (Displacement, temperature, acceleration, force/pressure) based on static and dynamic characteristics.

Actuators Selection of actuators based on principle of operation, performance characteristics, maximum loading conditions, safety etc. Principle and selection of mechano-electrical actuators

Low cost Automation circuits

Pneumatic devices Different types of valves, Actuators and auxiliary elements in Pneumatics their applications and use of their ISO symbols, Synthesis and design of circuits (up to 2 cylinders)–pneumatic, electro- pneumatics, Electro-pneumatic actuator, control valves, valve sizing valve selection. Electrical actuating systems solid-state switches, solenoids.

Microprocessor & Microcontroller System Theory

Microprocessor Introduction to Microprocessors, microcomputer and single chip microcomputer, Components of Microprocessor Registers, ALU and control & timing, CPU, I/O devices, clock, memory, bussed architecture, tri-state logic, address bus, data bus and control bus,. Architecture of 8085 Microprocessor,. Instruction Set,. Assembly Language Programming,. Advanced Microprocessors (RISC and CISC Architecture, Intel advanced microprocessors, ARM and SUN SPARC)

Microcontroller Introduction to Microcontroller and its families, Criteria for Choosing Microcontroller. Microcontroller Architecture, Programming model, Addressing modes, Instruction sets, Assembly and C programming for Microcontroller, I/O programming using assembly and C language, Interrupt Controller, I/O interfacing, Timers, Serial Communication, LCD Controller. Different types of Sensors. Microcontroller Interfacing Introduction to Microcontroller Interfacing and applications case studies Display Devices, Data Acquisition Systems, controllers and Drivers for DC, Servo and Stepper Motor

Control System

Control system design and analysis by Root Locus Method, P, I and D control actions, P, PI, PD and PID control systems, Transient response- Percentage, overshoot, Rise time, Delay time, Steady state error, PID tuning (manual)

Discrete Control System PLC (Programming Logic Control) Theory

Introduction to PLC, Architecture, Ladder Logic programming for different types of logic gates, Latching, Timers, Counter, Practical Examples of Ladder Programming.

Research Assignment

Each team of 4-5 students will submit a case study of a mechatronics device. The research assignment will constitute collection of literature, model of the device, development of the mathematical model and its controller design for different control tasks. Finally, each team has to submit a detailed report along with a presentation. The team can demonstrate the case. SIMULINK is a graphical environment for modelling, simulation, and analysis of dynamic systems, and is available as an extension to MATLAB.

Recommended Reading

1. Mechatronics by W. Bolton; Addison Wesley Longman Pvt. Ltd.
2. Gaonkar R. S., Microprocessor Architecture, Programming and Applications
3. Automation Production System and CIMS by Mikel P Groover; Prentice Hall.
4. Mechatronics by Hegde; Jones and Bartlett
5. Applied Mechatronics by Samili and Mrad Oxford University Press
6. Design with Microprocessors for Mechanical Engineers by Stiffler McGraw-Hill
7. C.W.De Silva, Mechatronics An Integrated Approach, Publisher CRC

Programme Name	<i>Master of Technology in Mechanical Engineering with specialization in CAD/CAM & Automation</i>
Course Code	MECC5042S
Course Title	Product Lifecycle Management

Course Outcomes

After completion of course, students would be able to

1. Understand the different element of PLM system.
2. Evaluate and select the proper PLM system as per the need of organization
3. Apply and design the various strategies for process and product data management

Course Contents

Introduction

Introduction, What is a product?, PLM What is it?, Product Lifecycle Management background Corporate challenges Product data or Product information.

Product Lifecycle Management (PLM), Product lifecycle management concept, Items, Product lifecycle management systems, System architecture, Information models and product structures, Information model, The product information (data) model, The product model, Reasons for the deployment of PLM systems

Product lifecycle management systems

Functionality of the systems, Use of product lifecycle management systems in different, organization verticals, Product development and engineering, Production, After sales, Sales and marketing, Sub-contracting, Sourcing and procurement. Product structures Product structure of a ship, Product structure of a cellular telephone, Product structure of a customizable product, Product structure of a configurable service product

Integration and Deployment of the PLM system

Different ways to integrate PLM systems, Transfer file, Database integration, System roles, ERP, CAD, Configurators, EAI etc. Different stages of deployment, Study of present and objective processes (AS IS and TO BE), Choosing a system, Realization stage of the project, Accomplishing change in the organization.

Challenges of product management in manufacturing industry

Special challenges of product management in the high tech industry, Case 1 Electronics manufacturer, Case 2 An engineering product, Frame of reference for product management, Developing product lifecycle management in project workshop Plc, The advantages and development potential brought by the product lifecycle management system, Case 3 Capital goods manufacturer and customer-specifically variable product

Service industry and the role of product information management in collaborative business development

Introduction, What is a service?, PLM in service business, Case 4 An IT-service (managed services) provider and a customer-specifically variable product. CIM Computer integrated manufacturing, CE

Concurrent engineering, Product lifecycle management as an enabler of cooperation between companies, Contents of collaboration, Successful cooperation, Tools of collaboration, CPC, ePDM, etc.

Recommended Reading

1. Antti Saaksvuori, AnselmiImmonen, Product Life Cycle Management - Springer, 1st Edition (Nov.5, 2003)
2. Grieves, Michael, Product Lifecycle Management, McGraw-Hill, 2006. ISBN 0071452303
3. Stark, John. Product Lifecycle Management Paradigm for 21st Century Product Realization, SpringerVerlag, 2004. ISBN 1852338105

Programme Name	<i>Master of Technology in Mechanical Engineering with specialization in CAD/CAM & Automation</i>
Course Code	MECC5043S
Course Title	Machine Tool Design

Course Outcomes

After completion of course, students would be able to

1. Analyze various components of machine tool and their applications
2. Understand fundamental concepts in machine tool design
3. To know about various common techniques used in design of machine components.

Course Contents

Introduction

Kinematics of different types of machine tools; selection of cutting conditions and tools; calculation of cutting force on single point and multipoint tools; hole machining, calculation of power; accuracy requirements and standards.

Design of Machine Tool Drives

Selection of Electric Motor, Stepped Regulation of Speed, Laws of Stepped Regulation, Why Geometric Progression is used against Arithmetic, Harmonic & Logarithmic despite shortcomings, Relation between Range ratio, Geometric Progression Ratio and No. of Speed Steps, Design of Stepped Drives-Break up of Speed Steps, Structural Formulae, Structural Diagram, Selection of Best Structural Diagram, Ray Diagram, Speed Chart, General recommendations for Developing the Gearing Diagram, Determining the number of teeth of Gears,

a) Speed Gear box Limiting Transmission Ratio of Speed Gear Box, Design Case Study of Speed Gear Box for Lathe, Classification of Speed Gear Boxes

b) Feed Gear box Limiting Transmission Ratio of Feed Gear Box, Design Case Study of Feed Gear Box (with Gear Cone & Sliding Key) for Drilling Machine, Classification of Feed Gear Boxes, Study of Application of Norton's & Meander's Mechanism for Thread Cutting Step less Drives-Step less Regulation of Speed & Feed Rates through Hydraulic, Electric & Mechanical means, Positively Infinitely Variable Drive, Case Study of CNC Lathe with Electronic Controller for Speed & Feed Step less Regulation

Controllers

Types, characteristics of controllers and their selection; ball screws and friction screws-guide ways; linear motion systems; design calculations of drives; closed- loop operations of feed drives; linear indexing drives; control elements single and multi axis CNC controllers; hydraulic control, pneumatic control; limit switches; proximity switches; sequencing Control using hard wired and PLC systems.

Design of Machine Tool Structures

Static and dynamic stiffness; dynamic analysis of cutting process; stability, forced vibration, ergonomics and aesthetics in machine tool design; design of spindle and spindle supports function of spindles; design requirements; standard spindle noses; design calculations of spindles; bearing selection and mounting.

Design of Special Purpose Machines

Design of a typical SPM Machines Example; CNC and transfer machines

Recommended Reading

1. Mehta, NK, Machine Tool Design and Numerical Control Tata McGraw Hill
2. Koenigsberger F., Design Principle of Cutting Machine Tools, Pergamon Press
3. Basu, SK and Pal, DK, Design of Machine Tools, Fourth Ed., Oxford and IBH
4. Acherkan, N, Machine Tool Design Vol I-IV, Mir Pub Moscow
5. Sen, G C and Bhattacharya, A, Principals of Machine Tools, New Central Book Agency

<i>Programme Name</i>	<i>Master of Technology in Mechanical Engineering with specialization in CAD/CAM & Automation</i>
Course Code	MECC5044S
Course Title	Product Design and Development

Course Outcomes

After completion of the course students will be able to

1. Students should be able to design a product using computer aided design.
2. Students should be able to carry out product development and planning process.
3. Students should be able to understand the concept of prototyping.

Course Contents

Introduction

Definition of Product Design, Design by Evolution, Design by Innovation, Essential Factors of Product Design, Production-Consumption Cycle.

Product Design Practice and Industry

Introduction, Product Strategies, Time to Market, Analysis of the Product, The Three S's Standardization, Renard Series (Preferred Numbers) Simplification, The Designer and His Role, The Designer Myth and Reality, The Industrial Design Organization, Basic Design Considerations, Problems faced by Industrial Designer, Procedure adopted by Industrial Designers, Types of Models designed by Industrial Designers, What the Designer contributes, Role of Aesthetics in' Product Design, Functional Design Practice.

Economic Factors Influencing Design

Product Value, Design for Safety, Reliability and Environmental Considerations Manufacturing Operations in relation to Design, Economic Analysis, Profit and Competitiveness, Break-even Analysis, Economics of a New Product Design (Samuel Eilon Model).

Human Engineering Considerations in Product Design

Introduction, Human Being as Applicator of. Forces, Anthropometrics Man as Occupant of Space The Design of Controls, The Design of Displays, Man/Machine Information Exchange.

Recommended Reading

1. A. K. Chitale, & R.C. Gupta, Product Design & Manufacturing, 2nd Ed 2002, Prentice Hall of India
2. Karl T. Ulrich, Steven D. Eppinger, Maria C. Yang, Product Design and Development , Mc Graw Hill, 7th Edition, 2020

Programme Elective-IV

Programme Name	<i>Master of Technology in Mechanical Engineering with specialization in CAD/CAM & Automation</i>
Course Code	MECC5051S
Course Title	Advanced Composite Materials

Course Outcomes

After completion of the course students will be able to

1. Identify the properties of fiber and matrix materials used in composites.
2. Select an appropriate manufacturing process for composite parts.
3. Analyse the performance of fiber composites based on the constituent properties.
4. Model the behaviour of composite materials
5. To study nanocomposites processing and properties

Course Contents

Introduction to Composites

Introduction to material selection in design, Types of composite materials, general characteristics of composite materials, applications of composites

Constituents of Composite

Materials Reinforcement and fillers glass fibers, carbon fibers, organic fibers, boron fibers, natural fibers, ceramic fibers Matrix thermoset matrix and thermoplastic matrix, metal matrix materials, ceramic matrix materials

Manufacturing of Composites

Bag-molding, compression molding, pultrusion, filament winding, liquid composite molding, resin film infusion, additive manufacturing of short fiber and long fiber composites, metal matrix composite manufacturing, ceramic matrix composite manufacturing, selection of manufacturing method

Mechanics of Fiber Reinforced Composite Materials

Fiber matrix interaction, micromechanics of composite materials, Laminate Analysis, Failure theories for composite materials, introduction to world-wide failure exercise of composites

Characterization of Fiber Reinforced Composite Materials

Static mechanical properties, fatigue properties, impact properties, methods of characterization of fiber-matrix interphase, quality inspection methods, different ASTM standards

Fracture and Fatigue of Fiber Reinforced Composite Materials

Failure of composites, delamination in composites, modes of fracture, composite damage mechanics, S-N diagram for composite materials

Polymeric Nanocomposite

Introduction to nanomaterials, nanoplatelete/nanoparticles/nanofibers reinforced composites, CNT/Graphene reinforced composites, processing of nanocomposites, prediction of properties of nanocomposites, applications of nanocomposites

Modeling of Composite Materials

Empirical models for prediction of mechanical properties of composites, finite element based modelling of short fiber and long fiber composites, Introduction to ANSYS ACP module for composite analysis, Simulation of short fiber reinforced composites using Digimat

Recommended Reading

1. P.K. Mallick, Fiber-Reinforced Composites Materials, Manufacturing, and Design, Third Edition, CRC Press, 2007
2. K. K. Chawla, Composite Materials Science and Engineering, Springer, 2012
3. Ever Barbero, Finite Element Analysis of Composite Materials using ANSYS, CRC Press, 2013
4. Hussain, Farzana, et al., Review article polymer-matrix nanocomposites, processing, manufacturing, and application an overview. Journal of composite materials 40.17, 2006 1511-1575
5. M. Ashby, Material Selection in Mechanical Design, 4th Edition, Elsevier, 2010

Programme Name	<i>Master of Technology in Mechanical Engineering with specialization in CAD/CAM & Automation</i>
Course Code	MECC5052S
Course Title	Design for Additive Manufacturing

Course Outcomes

After completion of the course students will be able to

1. Select appropriate material during design process
2. Identify the need of design for additive manufacturing
3. Identify design constraints and choose a polymer and metal AM process
4. Develop lattice structures using topology optimization
5. Apply design for AM guidelines in designing products
6. Apply design for AM techniques for manufacture of composites

Course Contents

Materials Selection in Design

The families of Engineering materials, the selection strategy, attribute limits and material indices, the selection procedure, computer-aided selection, shape factors, Microscopic or micro-structural shape factors, limits to shape efficiency, exploring and comparing structural sections, material indices that include shape, co-selecting material and shape, case studies

Introduction to Design for Additive Manufacturing (DfAM)

Introduction to geometric modelling, Modelling of Synthetic curves like Hermite, Bezier and B-spline, Parametric Representation of freeform surfaces, Design freedom with AM, Need for Design for Additive Manufacturing (DfAM), CAD tools vs. DfAM tools, Requirements of DfAM methods, General Guidelines for DfAM, The Economics of Additive Manufacturing, Design to Minimize Print Time, Design to Minimize Post-processing.

Design Guidelines for Part Consolidation

Design for Function, Material Considerations, Number of Fasteners, Knowledge of Conventional DFM/DFA, Assembly Considerations, Moving Parts, Part redesign, Opportunities for part consolidation, challenges with part consolidation.

Design for Improved Functionality

Multi scale design for Additive manufacturing, Mass customization, Biomimetics, Generative design, Design of multi-materials and functionally graded materials.

Design for Minimal Material Usage

Topology Optimization, Modelling of Design space, defining design and manufacturing constraints, performing analysis for weight reduction, maximize stiffness, minimize displacement, Post-processing and Interpreting Results, Applications of TO, TO tools, Design of cellular and lattice structures, Design of support structures.

Computational Tools for Design Analysis

Considerations for Analysis of AM Parts, Material Data, Surface Finish, Geometry, Simplifying Geometry, Mesh-Based Versus Parametric Models, Build Process Simulation Model Slicing, Contour Data Organization, Layer-by-Layer Simulation, Hatching Strategies, Scan Pattern Simulation and Tool Path Generation

Design for Polymer AM

Anisotropy, Wall Thicknesses, Overhangs, Support Material, Accuracy, Tolerances, Layer Thickness, Resolution, Print Orientation, Warpage, over sintering, Hollowing Parts, Horizontal Bridges, Connections, Fill Style, holes, fillets, ribs, font sizes and small details.

Design for Metal AM

Powder Morphology, Powder Size Distribution, Material Characteristics, Designing to Minimize Stress concentrations, Residual Stress, Overhangs, shrinkage, warpage and Support Material, Design Guidelines for Wall Thickness, Clearance Between Moving Parts, Vertical Slots, Circular Holes, fillets, channels, vertical Bosses, circular pins, External Screw Threads and part positioning.

Design for Additive Manufacturing of Composites

Additive manufacturing of polymeric composites using different processes, Design for AM of composites, Digital Composites, AI-driven/data-driven approaches for AM fabricated polymeric composite process

Introduction to DfAM using softwares

Introduction to additive manufacturing simulation tools of commercial softwares such ANSYS Additive Suite, Digimat AM-eXtreme, and Solidworks, Case studies on DfAM using commercial softwares

Recommended Reading

1. A Practical Guide to Design for Additive Manufacturing, Diegel, Olaf, Axel Nordin, and Damien Motte, Springer, 2020.
2. The 3D Printing Handbook Technologies, Design and Applications, Redwood, Ben, Filemon Schoffer, and Brian Garret, 3D Hubs, 2017.
3. Design for Advanced Manufacturing Technologies and Process, Laroux K, Gillespie, McGrawHill, 2017.
4. Additive Manufacturing Technologies, Gibson, Ian, David W. Rosen, Brent Stucker, and Mahyar Khorasani, Springer, 2021.
5. Additive Manufacturing Technologies, Gibson, Ian, David W. Rosen, Brent Stucker, and Mahyar Khorasani, Springer, 2021.
6. Laser-Induced Materials and Processes for Rapid Prototyping, L.Lu, J. Y. H. Fuh and Y.S. Wong, Springer, 2001.
7. Mathematical Elements for Computer Graphics, David F. Rogers, J. A. Adams, TMH, 2008.
8. Materials Selection in Design, Michel Ashby, 2011
9. ANSYS Granta, Edupack Manual
10. Hangqin Yuan, Shaoying Li, Jihong Zhu, Yunlong Tang, Additive manufacturing of polymeric composites from material processing to structural design, Composites Part B Engineering, Volume 219, 2021,

Programme Name	<i>Master of Technology in Mechanical Engineering with specialization in CAD/CAM & Automation</i>
Course Code	MECC5053S
Course Title	Manufacturing System Simulation

Course Outcomes

At the end of the course, the student will be able to

1. Classify analytical and simulation models used in manufacturing system environment
2. Apply probability and simulation languages
3. Design and evaluate a given manufacturing system using simulation
4. Generate random numbers and variants to execute a simulation model
5. Evaluate queuing networks and Markov chains in the context of manufacturing

Course Contents

Introduction to System and simulation

Concept of system and elements of system, Discrete and continuous system, Models of system and Principles of modeling and simulation, Monte carlo simulation, Types of simulation, Steps in simulation model, Advantages, limitations and applications of simulation, Applications of simulation in manufacturing system

Review of statistics and probability

Types of discrete and continuous probability distributions such as Geometric, Poisson, Uniform, Normal, Exponential distributions with examples.

Random numbers

Need for RNs, Technique for Random number generation such as Mid product method, Mid square method, and Linear congruential method with examples

Test for Random numbers

Uniformity - Chi square test or Kolmogorov Smirnov test, Independency- Auto correlation test
Random Variate generation Technique for Random variate generation such as Inverse transforms technique or Rejection method

Analysis of simulation data

Input data analysis, Verification and validation of simulation models, Output data analysis

Simulation languages

History of simulation languages, Comparison and selection of simulation languages

Design and evaluation of simulation experiments

Development and analysis of simulation models using simulation language with different manufacturing systems

Queueing models

An introduction, M/M/1 and M/M/m Models with examples, Open Queueing and Closed queueing network with examples

Markov chain models and others

Discrete time markov chain with examples, Continues time markov chain with examples, stochastic process in manufacturing, Game theory

Recommended Reading

1. Discrete Event System Simulation, J.Banks, J.S. Carson, B. L. Nelson and D.M. Nicol, PHI, New Delhi, 2009.
2. Simulation Modeling and Analysis, A.M. Law and W.D.Kelton, Tata McGraw Hill Ltd, New Delhi, 2008.
3. Performance Modeling of Automated Manufacturing Systems, N. Viswanadham and Y. Narahari, PHI, New Delhi, 2007.

Programme Name	<i>Master of Technology in Mechanical Engineering with specialization in CAD/CAM & Automation</i>
Course Code	MECC5054S
Course Title	Virtual Reality, Augmented Reality & Mixed Reality

Course Outcomes

At the end of the course, the student will be able to

1. Understand Geometric Modeling and Virtual Environment
2. Study about Virtual Hardware and Software
3. Develop Virtual Reality, Augmented Reality and Mixed Reality Applications

Course Contents

Introduction to Virtual Reality (VR)

Definition and Introduction, 3D animation and Augmented reality, Four Key Elements, Input devices, Output devices, Immersive and Non-Immersive Virtual Reality , Advantages & Disadvantages.

Interaction in VR

Human Factors in VR, Methodology and Terminology, User Monitoring , Degrees of Freedom (DOF), User Performance Studies, VR health and Safety Issues, VR and Society, Human Computer Interaction, VR in psychology.

Interface to the Virtual World

Glossary of VR terminology, Visual Displays, Head Mounts Display (HMD), Boom, Cave, Input Devices and Sensual Technology, Characteristic of Immersive VR Shared Virtual Environments.

VR Hardware & Integration

Key Interactions Manipulation, Navigation, and Communication, Trends in VR Hardware, Existing Hardware Technologies , Adaptability with Mobile devices, Visualization technology-, VR with 3D, VR with Anaglyph.

VR in Business

VR for Everyone, Mainstream VR Business, Adoption in Gaming Industry, Entertainment, Sports, Feature Films, Retail, Social media, education.

VR Videos and Streaming Applications

Virtual surround sound, 360 degree cameras, editing 360 videos, streaming, Virtual Reality Applications, Applications of Virtual Reality, Gesture Recognition, Education & training, Entertainment, Medical applications.

VR Authoring

Computational Fluid Dynamics (CFD) –Games– Virtual sets Costing – Virtual Reality Markup Language – Computing architecture for VR - Past, present & future of VR.

Future Adaptations of VR/AR/MR

Emerging Fields in VR/AR/MR –Industry Expert Talk, Mixed Reality (Mixed Reality Continuum , AR to VR, Mixed Reality Technologies.

Exercises/Demonstrations List of Exercises (Indicative)

Creating Virtual Environment, Interactive VR for Head Mount Displays (HMDs), Building a VR Game, Building VR APK & Testing, Immersive 360 degree view.

Recommended Reading

1. William R Sherman, Alan B Cranig, Understanding Virtual Reality Interface, Application and Design, Morgan Kaufmann Publishers, 2018.
2. Linda Jacobson, Garage Virtual Reality, Sams Publishing, 1994.
3. Ken Pimentel, Kevin Teixeira,Virtual Reality, Windcrest McGraw-Hill, 1st Edition, 2003.
4. Zachary Hill, Virtual Reality Advances in Research & Applications, Nova Science Publishers Inc, 2016.
5. Mauricio Dela Orta, VIRTUAL REALITY How to Experience and Create Amazing VR Content, Eduvea, 2016.
6. Tony Parisi, Learning Virtual Reality Developing Immersive Experiences and Applications, O'Reilly, 2015.
7. John Vince, Virtual Reality Systems, Addison-Wesley. 1995.

Open Elective-II

Programme Name	<i>Master of Technology in Mechanical Engineering with specialization in CAD/CAM & Automation</i>
Course Code	MECC5063S
Course Title	Robotics

Course Outcomes

After completion of course, students would be able to

1. Analyze various types Robots and their applications
2. Understand terminologies related to Kinematics of Robotics.
3. Analyze basics of motion programming as per kinematics
4. Apply logic for selection of robotic systems and its application.

Course Contents

Introduction to Robotics

Brief History, Basic Concepts of Robotics such as Definition , Three laws, Elements of Robotic Systems i.e. Robot anatomy, DOF, Misunderstood devices etc., Classification of Robotic systems on the basis of various parameters such as work volume, type of drive, etc., Associated parameters i.e. resolution, accuracy, repeatability, dexterity, compliance, etc., Introduction to Principles & Strategies of Automation, Types & Levels of Automations, Need of automation, Industrial applications of robot. Robotics application current and future.

Grippers and Sensors for Robotics

Grippers for Robotics - Types of Grippers, Guidelines for design for robotic gripper, Force analysis for various basic gripper systems. Sensors for Robots - Types of Sensors used in Robotics, Classification and applications of sensors, Characteristics of sensing devices, Selections of sensors. Need for sensors and vision system in the working and control of a robot.

Drives and Control for Robotics

Drive - Types of Drives, Types of transmission systems, Actuators and its selection while designing a robot system. Control Systems Types of Controllers, Introduction to closed loop control

Robot Kinematics

Spatial Descriptions positions, orientations, and frame, mappings changing description from frame to frame, Operators translations, rotations and transformations, transformation arithmetic, compound Transformations, inverting a transform, transform equations, Euler Angles, Fixed Angles, Euler Parameters. Manipulator Kinematics, Link Description, Link to reference frame connections, Denavit-Hartenberg Approach, D-H Parameters, Position Representations, Homogeneous Transformation Matrix, Forward Kinematics. Inverse Kinematics, Geometric and analytical approach.

Trajectory Planning

Introduction, path vs trajectory, joint space vs Cartesian space description, basics of tractor planning, joint space trajectory planning Third order polynomial, Fifth order polynomial, linear segment with parabolic blends, linear segment with parabolic blends and via points, higher order trajectories, etc.

Computer vision for robotic system

Imaging Components, Image Representation, Hardware Considerations, Picture Coding, Object Recognition and Categorization, Software Considerations, Need for Vision Training and

Adaptations, Review of Existing Systems, etc.

Computer Considerations for Robotic Systems

Objectives, Motivation, Architectural Considerations, Hardware Considerations, Computational Elements in Robotic Applications, Real-Time Considerations, Robot Programming, Path Planning, etc.

Related Topics in Robotics

Socio-Economic aspect of robotisation. Economical aspects for robot design, Safety for robot and standards, Introduction to Artificial Intelligence, AI techniques, Need and application of AI, New trends & recent updates in robotics.

Recommended Reading

1. Robert J Schilling, Fundamentals of Robotics Analysis & Control Pearson Education, Inc., 2007.
2. S. B. Niku, Introduction to Robotics – Analysis, Control, Applications, 3rd edition, John Wiley & Sons Ltd., 2020
3. R. K. Mittal, I. J. Nagrath, Robotics and Control, TATA McGraw Hill Publishing Co Ltd, New Delhi, 2003.
4. R. D. Klafter, Thomas A. Chmielewski, and Michael Negin, Robotic Engineering –An Integrated Approach, EEE, Prentice Hall India, Pearson Education Inc., 2009.
5. J. Angeles, Fundamentals of Robotic Mechanical Systems Theory Methods and Algorithms, Springer, 1997.
6. S. K. Saha, Introduction to Robotics 2nd edition, TATA McGraw Hills Education, 2014.
7. Ashitava Ghosal, Robotics Fundamental Concepts and Analysis, Oxford University Press, 2006.
8. T. C. Manjunath, Fundamentals of Robotics, Nandu Printers and Publishers, 2010.

Programme Name	<i>Master of Technology in Mechanical Engineering with specialization in CAD/CAM & Automation</i>
Course Code	MECC5064S
Course Title	Operations Research

Course Outcomes

At the end of the course, the student should be able to

1. Apply the dynamic programming to solve problems of discrete and continuous variables.
2. Apply the concept of non-linear programming
3. Carry out sensitivity analysis
4. Model the real world problem and simulate it.

Course Contents

Optimization Techniques

Model Formulation, models, General L.R Formulation, Simplex Techniques, Sensitivity Analysis, Inventory Control Models

Formulation of a LPP

Graphical solution revised simplex method - duality theory - dual simplex method - sensitivity analysis - parametric programming

Nonlinear programming problem

Kuhn-Tucker conditions min cost flow problem - max flow problem - CPM/PERT

Scheduling and sequencing

single server and multiple server models - deterministic inventory models - Probabilistic inventory control models - Geometric Programming.

Competitive Models

Single and Multi-channel Problems, Sequencing Models, Dynamic Programming, Flow in Networks, Elementary Graph Theory, Game Theory Simulation

Recommended Reading

1. H.A. Taha, Operations Research, An Introduction, PHI, 2008
2. H.M. Wagner, Principles of Operations Research, PHI, Delhi, 1982.
3. J.C. Pant, Introduction to Optimisation Operations Research, Jain Brothers, Delhi, 2008
4. Hitler Libermann Operations Research McGraw Hill Pub. 2009
5. Pannerselvam, Operations Research Prentice Hall of India 2010
6. Harvey M Wagner, Principles of Operations Research Prentice Hall of India 2010

Laboratory Courses

Programme Name	<i>Masters of Technology in Mechanical Engineering with Specialization in CAD/CAM & Automation</i>
Course Code	MECC5074L
Course Title	Laboratory-4 Advanced Finite Element Analysis Laboratory

Course Outcomes

After completion of course, students would be able to

1. To acquire basic understanding of Modeling and Analysis software .
2. Be able to use the commercial Finite Element packages to build and solve selected problems.
3. To understand the different kinds of static analysis, find out the stress and other related parameters.
4. To learn to apply the basic principles to carry out dynamic analysis.

List of Experiments/Assignments

1. 1-D Element Problems –Linear Static Analysis
2. 2-D Element Problems – Linear Static Analysis
3. 3-D Element Problems – Linear Static Analysis
4. Free Vibration Analysis on Beam, Bars, Plates
5. Non-Linear Analysis of 1-D Element Problems Like Beams, Bars
Thermal Analysis(Conduction, Convection and Insulation Boundary Conditions.
6. 1-D Element Problems-Steady state And Transient Analysis
7. 2-D Element Problems of Homogeneous and Composite Slap in Steady State and Transient Analysis
8. 3-D Element Problems Steady State Analysis
9. Project-Creating or Importing and Map Meshing of 3-D component /Assembly of practical application and FEA Analysis of Same component /Assembly

Recommended Reading

1. Finite Element Analysis using Ansys 11.0 by PaletiShrinivas, Krishna Chaitnay Sambana, Rajesh Kumar Datti.
2. Finite Element Analysis Theory and Applications with ANSYS by Saeed Moaveni
3. Engineering Analysis with ANSYS Software by Y. Nakasone and S. Yoshimoto
4. The finite element method And applications in Engineering using Ansys® by Erdogan Madenci, Ibrahim Guven
5. Practical Finite Element Analysis by Nitin Gokhale of M/S Finite to Infinite.
6. Reference Manual of Hypermesh Software
7. Online Tutorial HyperMesh Software
8. Tutorial of Ansys Software.

<i>Programme Name</i>	<i>Master of Technology in Mechanical Engineering with specialization in CAD/CAM & Automation</i>
Course Code	MECC5075L
Course Title	Laboratory-5 Mechatronics Laboratory

Course Outcomes

After completion of course, students would be able to

1. Construct basic pneumatic circuits.
2. Customize assembly programming for 8085 micro-processor and 8051 μ c.
3. Interface the 8051 μ c with the apparatus

List of experiments

1. Programming Assembly programming on 8085 for addition, subtraction and with carry etc.
2. Experiments on Pneumatic Trainer and on trial version of FESTO Software
3. Experiment on PLC Trainer
4. Interfacing with the 8051 using ADC, DAC, DC motor.

Programme Name	<i>Master of Technology in Mechanical Engineering with specialization in CAD/CAM & Automation</i>
Course Code	MECC5076L
Course Title	Laboratory Advanced Composite Materials Laboratory

Course Outcomes

After completion of the course students will be able to

1. Develop composite manufacturing process for the given part
2. Evaluate the performance of composite structure
3. Design the optimal composite structure

List of experiments

1. Resin Preparation and cure cycle
2. Manufacture of composite material using hand layup process
3. Manufacture of natural fibers composite materials
4. Open mold composite manufacturing process
5. Vacuum assisted resin transfer molding process
6. Manufacture of sandwich composite
7. Testing of polymeric composite materials
8. Finite element analysis of composite materials
9. Design optimization of composite structure
10. Manufacture of electrospun nanofibers reinforced composites

Text Books

1. P.K. Mallick, Fiber-Reinforced Composites Materials, Manufacturing, and Design, CRC Press, Third Edition, 2007
2. ANSYS Composite PrepPost User's Guide, <http://www.ansys.com>